Urosepsis After Percutaneous Nephrolithotomy (PCNL) - a New Prediction Rule and Scoring System

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Research

Keywords: percutaneous nephrolithotomy, urosepsis, risk assessment scoring system

Posted Date: October 18th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-963655/v1

Abstract

Objective:

Development and validation of a scoring system to predict the risk of urosepsis after percutaneous nephrolithotomy.

Methods:

The risk factors associated with urosepsis following PCNL(Percutaneous Nephrolithotomy) were identified by meta-analysis. Based on the degree of association, different scores were assigned to these risk factors. Finally Risk assessment scoring system for urosepsis after percutaneous nephrolithotomy (PCNL) was established and validated using ROC (Receiver Operating Characteristic) curve.

Results:

Based on the degree of association, Women, age (≥60yrs), diabetes mellitus, blood routine (White blood cells≥10×10^9/L), Urinalysis (White blood cells≥+), Urine culture (Positive), stone size(≥2cm), staghorn stone, hydronephrosis (moderate-severe) were assigned 3, 2, 3, 2, 2, 2, 2, 3, 2 points respectively with a total score of 21 points. The area under the ROC(Receiver Operating Characteristic) curve was 0.913, at the cut-off point of 8.5, the sensitivity and specificity were 90% and 89.4% respectively.

Conclusions:

The PuRass scoring system could be a useful tool in predicting the risk of urosepsis after PCNL(Percutaneous Nephrolithotomy). Clinician should pay attention to patients with a score above 8.5 during the perioperative period.

Introduction

Kidney stone was common urological condition affecting about 12% of the world population. Percutaneous nephrolithotomy (PCNL) was the treatment of choice for larger kidney and ureteric stones. Urosepsis was rare but devastating complication associated with this procedure and was very difficult to predict[1]. Understanding risk factors associated with of post-operative urosepsis was necessary to identify high-risk patients and better counsel patients pre-operatively. Clinicians and investigators had focused on pathogenesis, diagnosis and treatment of urosepsis following PCNL(Percutaneous Nephrolithotomy),but few attempts had been made in assessment and reorganization of the preoperative risk factors[2]. Thus, we developed a risk assessment scoring system (PuRass) to predict the risk of urosepsis following PCNL (Percutaneous nephrolithotomy) .

Materials And Methods

This study was conducted between January 2013 and December 2016 In Shihezi Medical college. In this study, we retrospectively included 293 patients with kidney stone who had undergone PCNL (Percutaneous nephrolithotomy).

Inclusion criteria: The diagnosis was made with either ultrasonography(USG) or computed tomography (CT), indication of surgery was based on 2014 Chinese diagnosis and treatment of urological disease guidelines.

Exclusion criteria: Cases of sepsis secondary to non-urological infection, urosepsis following percutaneous nephrostomy(PCNL).

Method

The population was divided into two groups urosepsis and the non-urological cause of sepsis. Risk factors associated with the development of urosepsis were identified using meta-analysis. Also, scores were assigned to risk these factors according to the degree of association. Finally, a risk assessment scoring system was established and validated using ROC(Receiver Operating Characteristic) curve.

The following criteria were assigned [3]

0.9≤OR≤1.0 or 1.0≤OR≤1.1 no association; 0.7≤OR≤0.8 or 1.2≤OR≤1.4 weak association; 0.4≤OR≤0.6 or 1.5≤OR≤2.9 moderate association; 0.1≤OR≤0.3 or 3.0≤OR≤9.0 strong association; OR<0.1 or ≥10.0 very strong association.

Degree of association: no association: 0, weak association: 1, moderate association: 2, strong association: 3, very strong association: 4

Preoperative data collection included Patient's demographics (sex, age), past medical history (Diabetes Mellitus,DM), Complete blood count, blood urea nitrogen, creatinine, liver function test, urinalysis, and urine culture were done. Imaging methods: Ultrasonography(USG) or computed tomography (CT) were used to determine stone size and location. Patients were evaluated using the newly established scoring system and receiver operating characteristic (ROC) curve and area under the ROC(Receiver Operating Characteristic)curve was used to determine the predictive ability of scoring system.

Statistical analysis

The database was established using Epidata 3.1, Statistical analysis was performed by using SPSS (SPSS Inc., Chicago, IL, USA, Version 17.0). Probability values <0.05 were considered significant. Continuous variables were presented as mean value and standard deviation for descriptive Statistics. Receiver operating characteristic (ROC) curve and area under the ROC (Receiver Operating Characteristic) curve was used to determine the predictive ability.

Results

Establishment of PuRass (Risk Assessment Scoring System)

The PuRass(Risk Assessment Scoring System)scale was established based on results of meta-analysis (Table.1.a) including the following nine risk factor: female, age (≥60), diabetes mellitus(DM), Full blood count (WBC ≥10×10^9/L), urinalysis(positive), Urine culture(positive), stone size(≥2cm), stag horn calculi, Hydronephrosis(moderate,severe) and they were assigned 3,2,3,2,2,2,2,3,2 respectively, with a total score of 21. (Table 1. b)

Table 1 a. Meta-analysis results of risk factors associated with urinary sepsis after PCNL

Research factors	Number of documents	Number of cases	Control number	Heterogeneity test		Model used	OR(95%*CI*)	Z	*P**
				P	I^2				
Gender: women	15	305	7915	P<0.10	76%	Random effect model	3.89 [2.07, 7.31]	4.22	*P*<0.05
Age(≥60 years old)	10	188	5860	P=0.52	0%	Random effect model	1.71 [1.23, 2.39]	3.17	*P*=0.02
Diabetes	8	228	5789	P=0.61	0%	Random effect model	3.15 [2.10, 4.72]	5.57	*P*<0.05
Blood routine (white blood cells ≥ 10 × 109 / L)	3	114	2624	P=0.72	0%	Random effect model	2.86 [1.66, 4.92]	3.78	*P*<0.05
Urine routine (white blood cell)	8	179	4723	P=0.08	45%	Random effect model	2.43 [1.35, 4.37]	2.96	*P*=0.003
Urine culture (positive)	8	168	4152	P=0.43	0%	Random effect model	1.60 [1.12, 2.29]	2.58	*P*=0.01
Stone size (≥2cm)	12	278	7196	P=0.98	0%	Random effect model	1.94 [1.49, 2.54]	4.85	*P*<0.05
Antler shaped stone	5	65	2511	P=0.68	0%	Random effect model	3.07 [1.78, 5.31]	4.02	*P*<0.05
Hydronephrosis (medium to severe)	5	102	1827	P=0.64	0%	Random effect model	1.57 [1.02, 2.43]	2.03	*P*=0.04
Hypertension	5	107	2999	P=0.86	0%	Random effect model	1.22 [0.78, 1.92]	0.88	*P*=0.38
History of stone surgery	7	181	3441	P=0.04	55%	Random effect model	1.39 [0.83, 2.32]	1.26	*P*=0.21
Whether to use antibiotics before surgery	2	97	1311	P=0.01	83%	Random effect model	0.77 [0.24, 2.53]	0.43	*P*=0.67

b. PuRass Scoring System

	Variable	Indices	Score	Grade	
Basic characteristics	Sex	Male	3		Total
		Female	0		
	Age	≥60 years	2		
		60 years	0		
Past history	Diabetes Mellitus(DM)	Positive	3		
		Negative	0		
Laboratory analysis	Blood routine (White blood cells)	$\geq 10\times10^9$/L	2		
		$<10\times10^9$/L	0		
	Urinalysis (White blood cells	Positive	2		
		Negative	0		
	Urine culture	Positive	2		
		Negative	0		
Imaging	Stone size	≥2cm	2		
		<2cm	0		
	Stag horn	Yes	3		
		No	0		
	Degree of hydronephrosis	Moderate severe	2		
		No/ mild	0		

Evaluation of risk assessment system

General clinical data

A total of 293 patients (99 men and 194 women) were evaluated using the newly established scoring system. The mean age was (50.41SD11.48) years and mean stone size (2.61SD1.64) cm. Among the ten case of urosepsis one patient died of complications. The reaming nine cases recovered well and discharged. The demographics are shown in Table 2.a.

Table 2 a. Patient characteristics undergoing PCNL

		Urosepsis	Non-urological cause of sepsis
Sex	male	7	92
	Female	3	191
Age	≥60 year	4	53
	<60 year	6	230
Diabetes Mellitus(DM)	With	3	16
	Without	7	267
Blood routine (White blood cells)	$\geq 10\times10^9$/L	7	30
	$<10\times10^9$/L	3	253
Urinalysis (White blood cells)	positive	9	59
	Negative	1	224
Urine culture	Positive	8	17
	Negative	2	266
Stone size	≥2cm	8	215
	<2cm	2	68
Stag horn	Yes	1	1
	No	9	282
Degree of hydronephrosis	Moderate severe	6	114
	No/ mild	4	179

b. PuRas scale of 293 patients

Group	n	Range	Mean	*t*	*p*
Urosepsis	10	4–16	11.70SD3.86	7.39	<0.01
Non-urological cause of sepsis	283	0–15	4.73SD2.90		

c. PuRass Grade stratification

	Urosepsis	Non-urological cause of sepsis	χ^2	*P*
Low risk	1（10.0）	249（88.0）	36.18	<0.01
Intermediate risk	6（60.0）	33（11.7）		
High risk	3（30.0）	1（0.3）		

Effect analysis of the Risk assessment system:

Two hundred and ninety-three patients scored between 0~16 points with an average score of (4.97SD3.19). The average score in urosepsis patient was higher than in non-urological cause sepsis and was statically significant (P<0.01) Table 2.b

ROC curve:

The predictive ability of the risk assessment system was determined by ROC(Receiver Operating Characteristic) curve with AUC 0.913 95%CI [0.807-1.000]). Youden's index (0.794) was used to determine the optimal cutoff values of 8.5 with a 90 % sensitivity and 89.4 specificity. See Figure 1

Degree of severity

For easier and accurate evaluation, severity was graded as Low risk 0-7; medium risk 8-14, high risk 15-21. All the 293 patients were assessed for degree of severity, the difference among the groups was significant(P<0.01). See Table 2.c

Discussion

Percutaneous nephrolithotomy (PCNL) was the treatment of choice for large renal calculi however, it was not free of complications. Urosepsis was a potentially catastrophic complication which could progress to multiorgan dysfunction syndrome (MODS). The risk of post-PCNL(Percutaneous Nephrolithotomy) urosepsis is 0.3-4.7% and has a mortality of 25-60%[4–5]. Delay in diagnosis and treatment of sepsis increased mortality, prolonged length of hospital stay, and increased the costs [6–7].

Incidence of urosepsis had increased with the increasing number of PCNL(Percutaneous nephrolithotomy) performed every year. Attempts had been made to identify factors contributing to the development of SIRS (Systemic Inflammatory Response Syndrome). However, no single method or scoring system had been designed to predict the probability of urosepsis[8]. Risk assessment tools had been widely used in disease diagnosis and prognosis[9]. Early diagnosis and treatment of urosepsis was difficult due to lack of a predictive scoring system. The development of evaluation system based on different risk levels that could help in early recognition of urosepsis, decrease its rate of complication and improve prognosis was today's need. This study aims to evaluate the risk factors associated to urosepsis after percutaneous nephrolithotomy (PCNL) and establish a risk assessment tools that could help in early diagnosis of high-risk patients and prevent septic complications.

Tian et al[10] included 164 post PCNL(Percutaneous Nephrolithotomy) patients to study infectious complications after percutaneous nephrolithotomy (PCNL) and established a prediction tool for postoperative complications. They proposed that patients with larger stone size and preoperative urinary tract infection were high risk patient of developing SIRS (Systemic Inflammatory Response Syndrome) and fever after the procedure. In a retrospective study[11] over a period of 3 years Sumit Suresh Bansal and colleges concluded that stone size >25 mm, prolonged operative time >120 min, and significant bleeding requiring transfusion were significantly correlated with postoperative severe sepsis. In anorther prospective study[11] to determine the predictors of infectious complications following PCNL(Percutaneous Nephrolithotomy), 332 patients with renal or upper ureteric calculi were divided into 2 groups depending on incidence of infectious complications. In patients with renal failure, diabetes mellitus, preoperative PCN (Percukaneous Nephrostomy) placement, staghorn calculi, severe HDN(Hemolytic Disease of the Newborn), multiple punctures, and prolonged duration of surgery. Post-PCNL(Percutaneous Nephrolithotomy)infectious complications were more commonly observed.

All these studies had some limitation mainly the small number of sample size, single center study and limited number of variables considered for evaluations. Retrospective study from single institute, which might lead to selection bias and cause-effect relationship between different biochemical parameters and co-morbid conditions were left out. Thus we

attempted to establish a scoring system based on the meta-analysis which including 12 factors and RCT (Randomized Controlled Trial) studies which was more accurate and comprehensive to establish a clinically useful evaluation system.

We carried a meta-analysis on risk factors of urosepsis following PCNL(Percutaneous Nephrolithotomy) and based on its results formulated the PuRass(Risk Assessment Scoring System) scale. In PuRass scale evaluation, post-PCNL(Percutaneous Nephrolithotomy) urosepsis group yielded higher score than in non urolological cause of urosepsis, indicating post-PCNL(Percutaneous Nephrolithotomy) urosepsis group prone to infection. The ROC(Receiver Operating Characteristic) cure with AUC (Area Under ROC Curve) 0.913 could effectively predict the probability of post-operative infection. At a cutoff value of 8.5 the specificity and sensitivity were 89.4% and 90.0% suggesting patients above the cutoff values having higher chance of acquiring post-operative infection. These were very important clinical information that could help urologist to prepare and take more precaution in these group of patients.

We performed risk assessment in 293 patients using the PuRass scale, majority of the post PCNL(Percutaneous Nephrolithotomy) patients were at moderate risk of urosepsis that was consistence to clinical practice and many published literatures.

But in majority of non-urological cause of urosepsis patients the score was low and there was a rapid decline in number of such patients with rise in the score. This helped surgeons to be more careful specially for high risk patients and avoiding associated complications.

Limitation of the study

The retrospective nature of the analysis from a region and a single institution might cause possible bias in the scoring system. Further verification from different regions or in multi center studies was needed before the widespread use of this evaluation score. Urosepsis following PCNL(Percutaneous Nephrolithotomy) depended on variety of the preoperative and perioperative factors. Earlier reports had identified number and size of tracts, bleeding, surgical time, irritants used, pelvic pressure, nephrostomy care as major factors associated with urosepsis[12–16]. But the surgeons experience and its association with incidence of urosepsis was not clear. Since preoperative factors played an important role in the incidence of urosepsis, the peri and postoperative factors were not included in the meta- analysis used to established this scoring system. Thus, this evaluation system might not be enough to precisely assess the risk of postoperative urinary sepsis.

We had developed a risk assessment system to assess the probability of urosepsis following PCNL(Percutaneous Nephrolithotomy). The clinical application and effectiveness were also validated. The risk assessment system was useful in quantification of the operative risk before surgery could help surgeons timely and accurate appraise the risk of postoperative urosepsis. It also enabled to screen high risk patients and strictly monitor these patients. Thus, this scoring system could identify the risk factors and guide to use appropriate measures to improve the prognosis of PCNL(Percutaneous Nephrolithotomy).

Declarations

1. Funding

Project level: National Natural Science Foundation of China (NSFC), **Project name:** Study on the mechanism of Casr-Claudin-14 - mediated nanobacteria induced renal calculus formation in experimental rats., **Project number:** 82060135;

Project level: Key project of Gannan Medical University, **Project name:** Role of selective regulation of Casr-Claudin-14 pathway in experimental kidney stone formation in rats, **Project number:** ZD201909;

Project level: The project of Shihezi University, **Project name:** Promotion and application of urological minimally invasive technology under the mode of "co-construction of departments" **Project number**: CGZH201810

Project level: The project of Shihezi University **Project name:** Study on the correlation between CaSR and nanobacteria induced HK-2 cell injury **Project number**:ZZZC201823A

2. Competing interests

This manuscript titled " **Urosepsis after percutaneous nephrolithotomy (PCNL) - a new prediction rule and scoring system**" has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal. All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

3. Availability of data and material

Not applicable

4. Authors' contributions

We declare that this work was done by the authors named in this article and all liabilities

5. Ethics approval and Consent to participate

This manuscript has not been published or presented elsewhere in part or in entirety and is not under consideration by another journal. All study participants provided informed consent, and the study design was approved by the appropriate ethics review board. We have read and understood your journal's policies, and we believe that neither the manuscript nor the study violates any of these. There are no conflicts of interest to declare.

All study participants provided informed consent.

6. Consent for publication

All study participants consent for publication.

7. Acknowledgements

This work is supported by the National Natural Science Foundation of China

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Figures

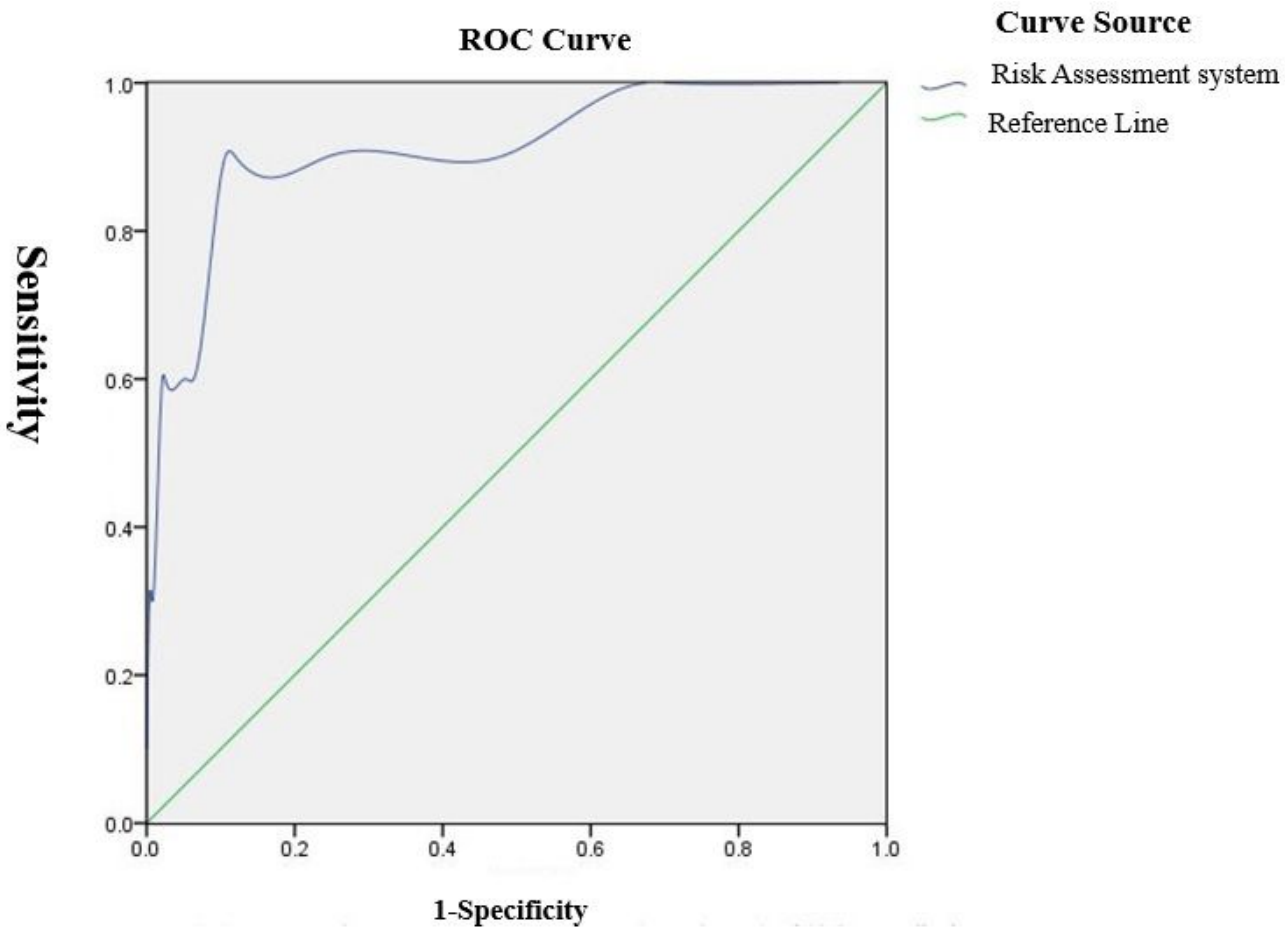

Figure 1

ROC curve of risk assessment system for urinary sepsis after PCNL